Stream Vietnam report 2003. Modeling the impact of land-use change on the runoff of the Perfume river basin (Vietnam) using STREAM

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2003

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Modeling the impact of land-use change on the runoff of the Perfume river basin (Vietnam) using STREAM

ITC refresher course and CCP 2003 Workshop on Geo-information for upland-lowland interactions in hydrological hazards and disasters

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Report number R-03/09

November, 2003

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ISBN 90-5383-902x

Contents

1. Introduction of the STREAM model

The STREAM model is a grid-based spatial water balance model for investigating water availability in river basins together with other aspects, such as interaction with coastal processes. The model has been applied to many larger river basins, such as the Ganges-Brahmaputra-Meghna in Asia, the Rhine in Europe, the Zambezi in Africa and the Yangtze in China. It has also been applied for coastal areas to estimate salt intrusion, for instance in Bangladesh.

The model uses script-files that can be easily modified by its users. For example, the model uses a rather simple equation to calculate evapotranspiration on the basis of temperature and soil parameters. It would be easy to update the model with better equations that make use of additional data on radiation, wind speed, humidity, etc. The current model was build around publicly available data that was collected from the Internet. In this manner, it is quite easy to set up the model in a short time period and without having to collect a huge amount of data.

The hydrological cycle of a drainage basin can be described as a series of storage compartments and flows. A water balance is often used as a framework to describe the transformation of input (precipitation) and output (runoff and evapotranspiration) through this cycle. These water balance components and the input parameters for the STREAM model are depicted the figure below.

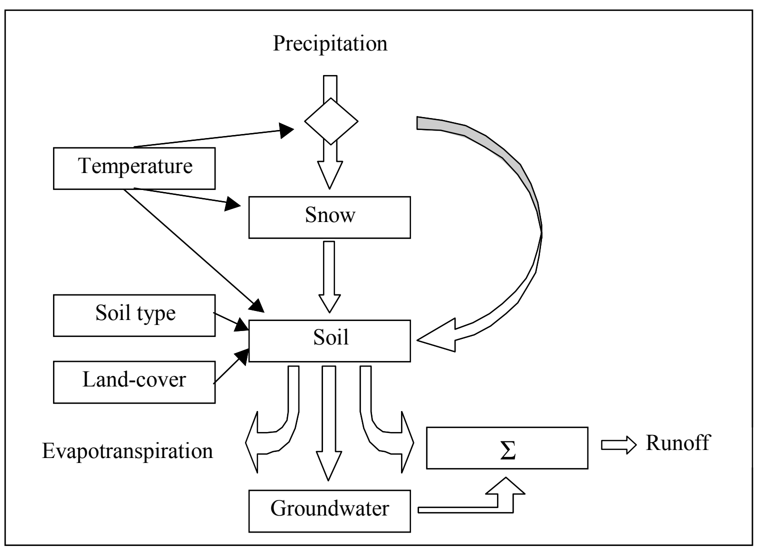


Figure 1.1. The water balance components of the STREAM model.

The water balance of river basins can be described by five major natural storages and controls:

1. The amount of precipitation and its spatial distribution;

2. The temperature distribution in the catchment, which mainly depends on the topography (elevation). This distribution forms the main control for the potential evapotranspiration in the catchment;
3. Soil moisture storage/shallow groundwater, which gains water from the surplus precipitation and loses water to evapotranspiration, to seepage to the deeper groundwater and to direct runoff;
4. Deeper groundwater storage, which gains water from the soil seepage and loses water to the river base flow;
5. The distribution of land-cover and soil water storage capacity in the catchment, which control the actual evapotranspiration.

For the simulation of the water balance the most important parameter besides precipitation is the actual evapotranspiration. To estimate the actual evapotranspiration ET_{act}, an estimate of a potential evapotranspiration is made. This is done by using the equation:

$$ET_{pot_{x,y,t}} = ET_{ref_{x,y,t}} \cdot k_{c\,x,y,t} \cdot F_{red} \text{, where} \tag{1.1}$$

ET_{pot} is the potential crop evapotranspiration,

ET_{ref} is the reference evapotranspiration, both in millimetre.

- k_c *is a crop coefficient, and*

F_{red} is a calibration parameter.

The maximum crop coefficient depends on the characteristics of the vegetation, depending land-cover, see also Section 2.4.

The STREAM model comprises the Thorntwaite equation, which determines the reference evapotranspiration using temperature data, according to the equations below:

$$\begin{gathered}\text{If } T \le 26.5 \text{ then } ET_{ref} = 16\left(10\frac{T}{H}\right)^{A}\text{, else} \\ ET_{ref} = -415.85 + 32.24 \cdot T - 0.43 \cdot T^2\end{gathered} \tag{1.2}$$

where T is the average monthly temperature in degrees Centigrade,

$$H = \sum_{jan}^{dec}\left(\frac{T_m}{5}\right)^{1.514}\text{, where}$$

T_m is the long term average monthly temperature from January to December, and

$$A = 0.49239 + 0.01792 \cdot H - 0.0000771771 \cdot H^2 + 0.000000675 \cdot H^3 .$$

Next, the actual evapotranspiration and the soil water balance are being calculated, this is done for each month. The actual evapotranspiration depends on the amount of water that is available in the soil and plants.

Within the model, the different inputs in the model to calculate the potential evapotranspiration are shown below. They are: a crop factor, the water holding capacity and temperature. In this exercise we will take a look at the <u>crop factor</u>.

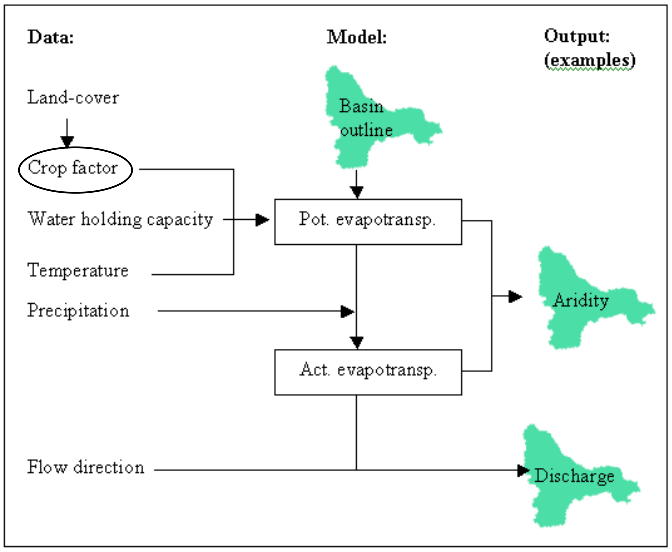


Figure 1.2 Model input data and processing.

2. Modelling exercise Perfume River using land-use change data

Aim: To assess and understand the impact of land-use change on hydrological regimes

Objectives:

- Use input data on land-use data from 1965, 1980 and 1996 (from the exercise on Friday) for a hydrological model;
- Simulate seasonal series of runoff in the TT Hue province (Vietnam) with a monthly time step using the STREAM modelling tool,
- Assess the changes.

2.1 Exercise 1. Explore the STREAM model.

Start the STREAM model using the short-cut on the desk-top. On the top there are several buttons.

When you click on the button Current Case you will see a screen with information on the <u>model properties</u>.

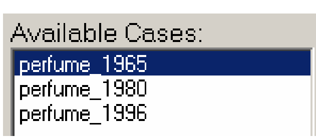
The simulation time, the number of months that are being run, can be selected using the box in the middle:

We use 36 months (three years) in order to get a stable, reliable output.

When you click on the button Calculation Script the <u>calculation script</u> appears.

2.2 Exercise 2. Explore the different climate data input and land-use maps

The different periods that we want to investigate are listed as different “cases” in the top left box:



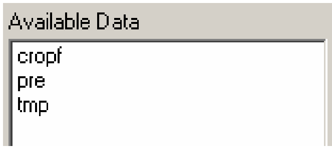
You can <u>select the different cases</u> by clicking on them with the mouse.

Take the case for <u>1965</u>. Now click on the button Input to see the <u>input files</u>.

There are three maps:

- The crop factor map: cropfactor
- The precipitation map: pre
- The temperature map: tmp

Click on each map to see the data:



Using the mouse you can zoom in (click the right mouse button), and you can return to the normal view by clicking the button 

.

Take a look at the precipitation map, click on pre.

Now scroll through the twelve different months using the button 

.

Question: During which months is most of the precipitation falling in the Perfume river basin?

Now click on cropf. When you look at the crop factor map, you will see the crop factors for the year 1965.

The different land-use classes that we investigated on Friday are now translated into numbers according to the list below:

Table 2.1 Land-use classes.

Year Source Class	1965 Aerial photo %	1980 Landsat MSS %	1996 SPOT %	Crop factor
2 Agricultural land	3.8	7.2	8.0	1.0
4 Close forest	20.4	0.8	1.1	1.2
5 Grass	0.0	0.0	0.0	0.8
6 Medium forest	0.0	0.2	0.2	1.1
7 Open forest	0.0	0.0	0.1	1.0
8 Other land	5.7	5.0	9.3	0.8
9 Plantation forest	0.4	4.9	1.9	1.0
10 Sandy	3.1	0.0	6.0	0.5
12 Settlement	0.0	2.3	1.7	0.8
13 Settlement and fruit	0.7	0.7	1.0	1.0
15 Shrub	0.0	8.2	0.5	0.8
16 Water	2.1	2.1	2.3	1.5
17 Wood land	2.4	7.3	6.5	1.0

Repeat this exercise for the year 1996.

To do this, first go back to the overview, by clicking the button 

. Now select 1996 in the top left box.

Click on the button the button 

to see the input files for 1996.

Question: Look at the crop factor map: are there any large differences with 1965?

2.3 Exercise 3. Run the model for 1965

With these three sets of data we now can run the model.

!! First make sure that the model is set at "1965" in the window [Current Case] **!!**

Click on the button [Run]. When you click on the button [Start Calculation] the model will start to run.

While the model is running, you will see the calculation script on the screen.

When the model is done, it says: `...End of iteration.`

2.4 Exercise 4. Assess the output

Click on the button [Output] to see the output.

There are two outputs given:

- The amount of actual evapotranspiration: AE;
- The maximum and average amount of water in cubic metres per second: DISQSEC.sum.

Now take a look at the amount of actual evapotranspiration and fill in the values. There are three years (36 months) being displayed

Question: What is the maximum during the highest month in 1965? ☐

Question: What is the average during the highest month in 1965? ☐

Now go back to [Current Case] and select the year of 1996.

Go to the [Output], and take a look at the actual evapotranspiration.

Question: What is the maximum during the highest month in 1996? ☐

Question: What is the average during the highest month in 1996? ☐

Now look at the different values of 1965 and 1996. Is this what you would expect?

TIP: Remember the land-use changes that we assessed on Friday. The removal of forest, what would that change for evapotranspiration?

Now take a look at the discharge of the rivers. Click on DISQSEC.sum under the [Output] button.

Question: What is the maximum during the highest month in 1965?

Question: What is the average during the highest month in 1965?

Now go back to Current Case and select the year of 1996.

Go to the Output, and take a look again at the discharge.

Question: What is the maximum during the highest month in 1996?

Question: What is the average during the highest month in 1996?

Now look at the different values of 1965 and 1996. Is this what you would expect?

TIP: Remember the land-use changes that we assessed on Friday. The removal of forest, what would that change for evapotranspiration?

References

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